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MAY, 1957 VOLUME 19, No. 5

Reading and Science Instruction
High School Student Research
Predatory Birds

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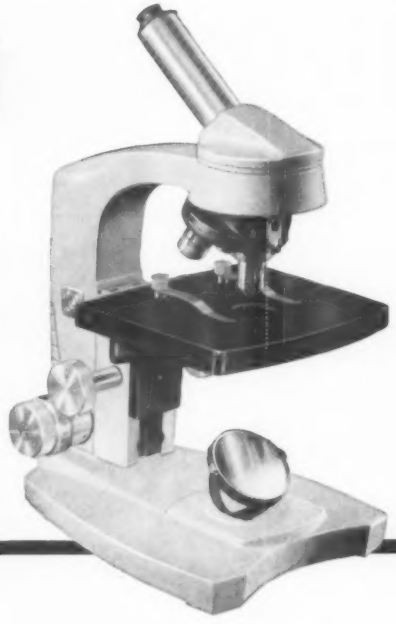

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Cover Photograph

A starling gets fed. Photograph by Richard Trump, Ames High School, Ames, Iowa.

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Reading and Science Instruction

KENNETH B. M. CROOKS
Professor of Zoology, The State College, Fort Valley, Georgia

IV. College Students' Misspelling of Common Words

Introduction

As a teacher of college science I used to be disturbed at the time I spent on fundamentals, such as reading, writing, spelling and arithmetic. I have corrected thousands of errors in grammar and composition and perhaps millions of spelling mistakes. After more than twenty-eight years of correcting college students' papers, I am no longer excited when I see a split infinitive. A new sentence begun with a lower case letter does not affect my blood pressure nor do such misspellings as *gimy pig*, *blud* or *nerse*.

Because I know the importance of proper English to a citizen, a boss and an employee (9), I am deeply concerned about the unfortunate young people who write these errors, especially since spelling seems to be getting worse (1, 17) and our education seems to be generally deficient. (5, 7).

Colleagues often ask why such concern in a science teacher. The answer: Unless students in science can read and understand their texts and references, they cannot master subject matter; unless they can explain orally and in writing what they have heard, seen or read, they cannot gain all the benefits of courses in science. Besides, many writers feel that every teacher should be a teacher of language. "Spelling is a perennial problem and the . . . 'demons' must be taught in the elementary school, reviewed systemically both in high school and college. (All teachers) must share the responsibility for the college student's ignorance of the spelling of common words." (17)

"Many school teachers feel that they should not teach reading. They do so only because (those in the grades lower than theirs) . . . failed to do a good job . . . . In my opinion, we shall never develop adequate reading programs until there is whole-hearted recognition that (reading) is the responsibility of *every* teacher in *every* field, at *every* level . . . through (to) the graduate school . . ." (10; italics mine).

One must go further. College teachers must help students "un-learn" errors; they must purge bad writing, and teach youngsters to spell as well as to add, subtract and multiply. College students bring so many gaps in tool subjects—which they should have mastered in school—that they leave too little time for creative science teaching in the subject matter of college science.

Poor reading, poor spelling and poor college work are closely related (24). In college classes, there are too many poor readers and poor spellers, and too many students who cannot pronounce a word of more than three syllables. If pupils have been taught to read well, orally and silently, they will, when they come to college, get much more of the effort of the science teacher.

Experiences in science should make students better citizens, broaden their outlook, prepare them for vocations and perhaps give some that peculiar exhilarating experience called *inspiration*. But one cannot inspire illiterates with a book—certainly not with a science book. It is hard to motivate poor readers. So is it with poor spellers. When they read, they do not understand or recall; and they cannot transmit well in writing the information they should have learned. Hence, they shun the science courses, for they are afraid of the "new" words, the "big" words, and the "hard" words they cannot read, pronouncé or spell (17).

The Problem

Flesch, in his controversial book (11) suggests that "reading and spelling are two sides of the same (coin) and the trouble starts as soon as you try to separate the two. The *only correct way to teach reading* (successfully) *is by teaching spelling at the same time.*"

Poor readers often are poor spellers, and

as the reverse is also true (24), poor spellers cannot benefit fully from science textbooks, nor can they use with proper benefit the classic sources, nor read worth-while science books. They are thrilled by films of Pasteur's life and researches, and they read comic books with enthusiasm, but they refuse books like Radot's "Life of Pasteur," deKruif's "Microbe Hunters," Sears' "Deserts on the March," and many others, which are fascinating to a good reader.

Because of their reading deficiencies, most students feel that all science books are too difficult. If they are persuaded to read a book, they get very little out of it. It seems clear that these related problems need urgent attention, especially when the less interesting textbooks are really difficult to read (26).

Materials and Method

For twenty-six years I have kept records of college students' misspellings. During this period I have taught about 7000 students in a variety of science courses in the field of Biology.

This paper deals with misspellings of 440 words found in Thorndike's list of 10,000 common words (18). These belong to everyday speaking, reading and writing, and should be in the vocabulary of every citizen who has had any schooling. No biological, technical or foreign words are included.

Most of these words have been misspelled by 300 different students or more, (not merely 300 times); some have been misspelled by 400 and many by more than 500 college students.

In the alphabetical list below, the word meant is given first; following it, in parentheses, are some of the most frequent misspellings. Though the printing of errors may be criticized, this list is justified, if it will call attention to the glaring errors. Teachers who know of these mistakes or understand why they are made, should help to improve the spelling of other students who wish to attend college.

Misspellings Omitted

Omitted from the list are obvious slips of the pen, such as the omission of a letter or the accidential switching of letters: for example, if *thraot* occurs in the early part of a report but *throat* thereafter. Though teachers should continually correct slipshod writing and careless spelling,—for they may impair the communication of ideas—they need not be perfectionists (19) or they may miss the forest while counting the trees.

When I first met the word *eathworm*, I felt that my students had omitted the *r* accidentally. However, several scores of other students frequently leave out the *r*, and convince me that they have not really learned to spell this word. This is a reflection on their powers of observation and on the kind of teaching they have received.

I have omitted hundreds of other words misspelled by students who failed my courses. Since a failing pupil may be deficient in ability, preparation, intelligence and personal persistence—the will to learn—he may write misspellings of common words known and correctly used by other students. (Also, many students did not pass my Biology courses because their spelling was outrageous—I can think of no better adjective.) Hence, though many spellings here listed are clearly "illiterate" (20), they were written by students who were able to satisfy me in subject matter. These errors deserve attention, for they are probably due to such factors as carelessness, inattention, wrong instruction or lack of instruction. Such weaknesses adversely affect the school, the college and the nation.

Findings

In preparing my list, I used two references, Thorndike's *Teacher's Word Book* (1927) and Gates' *Spelling Difficulties in 3876 Words* (1937). These two books deal with our common vocabulary and with words used in the grades; misspelling of such words seem therefore inexcusable in college students.

List of words, each misspelled by more than 300 college students (1931-1955)

A

ability (bility)
abdominal (abnomial; adbominal)
absence (absents, & vice versa)
absent (absence)
absorb (aborb; adsobe)
absorption (absorbation; absortion)
access (excess)
acid (asic; acit)
active (atvie; actrive)
afflicted (flicted)
against (agance)
alcohol (aklohol; alchohol; aclohol; acholo)

almost (allmost)
alligator (aligator; allagator)
alphabet (albeth)
already (allready; alredy)
always (allways)
among (amoung)
analysis (analasis; analisis)
ancient (acient; anceint)
angel (angle and vice versa)
animal (anamal; aminal)
answer (anser; ancer)
apparatus (apperatus; apporatus)
apparent (apparant)
appetite (apetite)
apt (ape)
arctic (artic)
are (or; ar)
anticipate (antisipate)
around (arond)
arm (alm)
artisan (artesian)
artist (artest)
atmosphere (astospmere)
ascend (assend; accend)
attach (attatch; attact)
attachment (attacment)
author (auther; arther)
available (avaiabl; avaible; availiable; avalable)
awkward (akward)

B

banana (banna; bananna)
beauty (buety)
beef (beaf)
behavior (behavier)
being (bean; beign)
belief (beleif; beleive)
believe (beleive; belive)
blood (blud; bood)
bleed (blead)
blossom (blosom; blossum)
body (boddy; boby; boley)
boiling (boilding)
botany (botamy; banady)
brain (brane; bain; brian)
brake (break)
bran (brand)
brand (bran)
break (brake)
breakfast (breakfuss; breakfusses)
breathe (breeze; breads)
brittle (brickle)
broken (browken)
bulb (blub)
buried (burried; berried)
burst (brust; bust)
business (buisness)

C

canal (cannal)
calendar (calandar; calender)
capacity (capasity; compacity)
camphor (camfer)
carriage (carrige; carraige)
cannon (canon)
carrot (carot)
careful (carefull)
cause (casze; course)
ceiling (cieling)
central (centeral)
chamber (chamble)
certain (sudden; certain)
chemical (chemisal; chemity)
cheek (cheak; cheeck)
circulation (curculation)
chest (chesk)
circle (curcle; curcue)
color (colur)
comb (cone; come)
combination (combanation; combantion)
coming (comming)
complete (complate; compleat; complet)
completely (completly)
compound (commpound; coumpound)
concern (consum; consern)
condition (condiction)
continuous (contineous)
copper (cooper)
coral (corral)
corpse (corps)
curve (curbl; cerve)
creation (ceration)
cylinder (cilender; cilinder)

D

dangerous (dangerious)
deaf (deaft)
decide (deside)
deer (daer; deers; dear)
definite (definate; definiate)
descend (decent; decend; desend)
describe (decribe; discribe)
destroy (destory; destroye; distroy)
develop (divilop)
dew (due)
different (distant; diffrent)
diagram (digram; dragram)
dining room (dinning room)
digestion (dijestion)
disease (diseadse; diasis; desease; diaese; diesease; diese; dease; desicse; diease; diaeses; deasees)
discover (decover)
distinction (distinguishion)
divine (devine)
doctor (dockler; docter)
does (verb) (doese)
distinguish (destinguesh)
do not (donot; dount)
dose (does)
double (dubble)
drawer (draw)
dropped (droped)
drunkard (dunker; drunker)
due (dew)
during (durning)
dwarf (dwaf)

E

earthworm (eathworm)
easily (easshy)
effect (efect)
eggs (egges)
else (ealse)
energy (engry; engery; energe; enegry)
environment (invirment; envoriment; envirement; envoirement; invirement; envirenment; envoirement; invirenment; envierment)
enough (enought)
everybody (everbody)
etc. (ect.; and ect.)
evaporate (evaperate; vaperate)
evidence (everdence)
everything (everthing)
existence (existance)
exist (exzest; exsist)
explanation (explaination)
experiment (expirement; experimed)
eyelid (eyelead)
extreme (extreem; extream)

F

face (phace; phase)
factories (facteries; factorys)
family (famaly; famly; fambly)
false (flase)
father (farther)
familiar (fimiliar)
feeble (feable)
farther (father)
fertilize (furtilize; fertilice)
February (febuary)
fifteen (fifthteen)
fern (furn; firn; firm)
fever (fevor; feaver; feavor)
finally (finially; finely; finly)
find (fine)
fine (find)
first (frist)
floating (flotting; flocking; flowting)
flour (flower)
following (follering; floowering; folloring)
food (fod; foot)
foreign (frogein)
forth (force)
front (frount)
fruit (frute)
function (funcation)
fundamental (fundimental)
funnel (funal)
furnish (furnush; funush)

G

gall (gaul; gual)
gape (gap; gaps)

gas (gass; gase)
gelatin (jellin)
gentleman (gentlman)
geography (goegraphy)
gland (gand)
goes (goze; gose)
graduate (gradurate)
grateful (greatful)
guinea pig (ginny pig)
growth (groth)

H

hair (hare)
handle (handel)
heel (heele)
heifer (herdphor)
heredity (hederity)
high (heigh)
hind (hine)
horizontal (horizone; horzontal; horizionial)
human (humman; humann)

I

idea (idear; ideal)
ideal (idea)
if (iff)
importance (impertance)
impulse (impluse)
impossible (imposible)
incidentally (insidently)
individual (individial)
injury (enjer)
intelligent (intellegent; intelligence)
internal (enternal)
intestine (intestants; intestances; intestion; intastance; intest; instenial)
iodine (idine; idoine; idone)
iris (irish)
irregular (irregital)
island (iland)

J

January (Januery)
jealous (jelous)
judgment (judment)
juice (jusice; jusic; juicies)

K

kidneys (kindnys; kindys)
knee (nee)
knowledge (knolodge; knolege)
known (none)

L

label (lable)
laboratory (labratory)
lead (metal) (led)
larynx (larnyx; lacaryx)
length (lenght)
leaf (leafe)
library (libary)
lens (len; lense)
liquid (liquard; liquod)
lion (loin)
loin (lion)
living (livining; liveing)
lost (loss)
loss (lost)

M

machine (mechine)
male (meal; mail)
marrow (merrow; moral; marol)
many (maney; meny)
material (meterial; matherial)
measure (mersure)
meat (meet; mete)
member (menber)
mineral (meneral; minerial; minearl; minerol)
mixed (mixtured)
modern (moden; morden; modren)
morsel (morsal; mosral)
muscle (mucile; muscule; muscel; muskle

N

needle (nedde; neddle)
neck (kneck)
neither (niether)
neighbor (nabor)
nervous (nurvous; nervious)
nerve (never; nurve)
niece (neice)
nine (nin)
nineteen (ninteen)
ninth (nineth)
nipple (nipper)
notice (notis)
nostril (nostral; nostrage)
numerous (numbrous; numberous)
nurse (nerse)

O

oil (iol; oll)
operation (oparation)
opposite (object; appossite)
or (are; ar)
origin (orgin)

P

pail (pale)
palm (plam; parm)
parasite (parsite)
peanuts (pennuts)
pen (pin)
pencil (pencle; pincle)
perforate (perfurate; perferate)
perform (preform)
pigeon (pigion)
pin (pen)
platelet (playlett)
planet (plant; plantes)
pollen (polen; polan)
poison (poisen)
possible (possiable)
position (prosition)
powerful (powful)
pregnant (preganant)
prejudice (predjist; prejdist)
presence (presents)
pressure (preasure)
pretty (pritty)
priest (preist)
privilege (privelege; priviledge)
problem (ploblem)
proboscis (probasic)
pumpkin (punkin; pumkin)
pulse (pluse)
pupil (pupel; puple)
puncture (puncrate)
pursuit (persute; persuit)
purplish (purpish)
pyramid (prymid; pymarid)

Q

queer (quear)
question (qustion)

R

receive (recieve)
recessive (ressive)
reddish (redish)
resistance (resistiance)
response (responace; responds)

S

sack (sak)
scene (schene; scheme)
sanitary (sanatary)
scissors (sissors)
science (sience)
search (serch; sertch)
scurvy (scurvery; scervy; scury; curvey)
seize (sieze)
seen (seened)
sensitive (sensative; senctive; sinitive)
seacoast (seacost)
serious (serous)
separate (seperate; seporate)
several (serval)
shaft (shelf; shaff)
sheep (plural: sheeps)
shining (shinning)
shook (shooke)
shoulder (sholder)
shows (showes)
silver (selver)
similar (similiar; simular)
simpler (simplier)
six (sex)
skeletal (skeletive)
sketch (seatch; scieth)
snail (snell; snale)
soluble (soluable)
something (somthing)
son (sun)
source (sourse)
specific (spefic)
specify (spefy)
specimen (specimens; specman)
spread (past tense: spreaded)

spherical (sperical; spericle)
stem (stim)
spleen (splene; spleem; splein)
stomach (stume; stormach; stomack)
starch (starh; strach; stach)
strategic (stragetic)
straighten (streighten)
strength (strenght)
stream (streem)
strength (strenght)
structure (sturcture)
studied (studyed)
studying (studing)
substance (subsance)
successor (successer)
sun (son)
sum (som)
surface (serface; sulface)
surrounded (surrendered)
sweat (sweet; swet)
swallowed (swallard; swalled)
system (systerm)
symbol (assemble; semble)
symmetrical (symetrical)

T

talent (talant)
tears (tiers)
task (tass)
temperature (tempature; temperture; tempurature; tempture)
temple (temper)
temporary (temperery; temperary)
theory (thero)
there (their; thene; thier)
thigh (thie; theigh)
think (thing; tink)
thirty (thrity)
thistle (thissel)
throat (thraot)
thought (though; throught; thooght; througt)
Thursday (Thrusday)
through (throw; throught; thourgh; *etc.*)
tiny (tiney; tinny)
thus (thrus)
tongue (tong; tung; tounge)
together (togeather; togather)
tough (tuff)
towards (towarge)
trachea (trecaker)
transparent (transperent)
travel (travil)
true (ture)
truly (truely)
tube (tub; twbe)
turned (turnt; turnd)
turnip (turnup; trunus)
two (tow; too)

U

until (tell; untill)

V

various (vary)
ventricle (venery; ventural)
veins (vain; vaint; veines)
vessel (vesseal)
vertebrate (vertibrate)
villain (villian)
vice versa (vice virus; visca verca; vise versa)
voluntary (volinatry; volintery)
volume (volumn; volum)

W

waste (waist; wase; wess; west)
wax (wask; wasck)
week (weak)
weak (week)
weather (whether; wehther; wether)
wharf (warf; worf)
wheat (weat)
where (were; whear)
whole (hole; hold)
whether (weather; wether; wheather)
which (wich; whitch)
womb (wound; woum)
whose (who's)
would (wood)
wrist (wriste; wist; risk; wrest; wraist)
writing (writting)

Discussion

The literature is full of evidence that college students do not read, write or comprehend printed material as well as they should. This study proves that they can not spell either. High School textbooks of English have rules for spelling, for making plurals and for hyphenation; college books list "frequently misspelled words,"—one (21) has over 600 words—yet many college students are still "Linguistic Delinquents" (5). Unfortunately, college faculties seem to be immune to this deterioration.

Businessmen know that the ability to read and spell are valuable. An illuminating episode is related in a pamphlet published by General Electric.* The top engineer telephones: "I have before (me) . . . a brief report from one of our young engineers. I have to guess . . . what the fellow is driving at. I am no English shark, but I find myself getting a little angry when I see four sentences tied into one with four commas. He has *principle* for *principal* and he has also misspelled *accommodate* and *Cincinnati*. What if some of this fellow's bad sentences get into the hands of our customers?" When an executive of a corporation which makes "diesel locomotives, turbines, generators, jet engines, refrigerators and 200,000 other electrical products," considers English and spelling vitally important, then it is time that teachers too begin to pay attention.

I have pondered over my long list, studied the literature, have had conferences with teachers and with the young people themselves, and feel that many factors lie at the root of this problem and contribute to poor spelling. The following are probably important.

Factors Which Probably Contribute To Poor Spelling

1. *Not Enough Drill.* School children are kept busy doing projects and participating in many kinds of activities. They raise money, put on programs, and develop rounded personalities, it is claimed, but many grow up

*"*G. E.'s Answer to Four Why's.*" Form PRD-45, page 6.

with wooden heads. Unless teachers resume intensive spelling study, and do remedial spelling and reading (7a; 13a) they are likely to make us a nation of illiterates. (When I find a "howler", I find out if my student really cannot spell his puzzler. In most cases, he first tries to substitute another word (17), but I make him stick to his word, "dissecting" it, explaining its derivation, or breaking it into syllables (13a). He then writes out the correct spelling ten or twenty times; after this, he is checked again. To be sure, a science teacher cannot afford to spend too much time on drill: he would teach no science. But he cannot accept careless reading and poor spelling. Science is too exact for that.)

2. *American Inventiveness.* Originality and shortcuts have played havoc with spelling. Streamlining has helped in transportation; job analysis and the work of efficiency experts have revolutionized living, but there are the concomitant evils of words like "thot," "thru", "nabor", and even such horrors as "Jaxnville" (Jacksonville). Teachers of the sciences must not tolerate such nonsense.

American culture is infected with a national disease, "sloganitis". Most slogans are puns or clever witticisms; some are homonyms; all are deadly for the young mind, which learns more out of school than in, for our schools now seem not to demand hard work (16a). Young people who are learning to read or are having spelling and reading troubles meet repeatedly such words as "Korn Kure", "All Nu", "Glo Cote", "Hi Fi", "Gleem", "Kwik-Chek", "Kannon Ball Xpress", "Filter Flo", "All Rite", "Champeen". To make matters worse, many slogans are accompanied by the magic letters, "Reg. U. S. Pat. Off."

3. *Many Teachers Feel that Spelling Is Not Their Responsibility.* Some even feel that spelling is "not important enough for a college teacher to waste time on." These are dangerous views. The student who writes *there* for *their* or vice versa is interchanging words he can spell (16). Obviously, his teachers must point out these differences and also distinguish between *two*, *too*, and *to*; *hare*, *hair*, *here*, *hear*, and *heir*. They must also identify the common blunders in words such as *receive* and *separate*. If the grade teacher does not, the high school teacher should; if she does not, the college teacher must. But if no teacher assumes the responsibility, then the student will have to learn out of school, teach himself, or become a statistic in our national illiteracy score.

4. *Widespread Use (And Abuse) of Objective Tests.* Colleges now accept from schools and send out as graduates hundreds of young people who have passed tests by filling out blanks, matching words or writing T or F beside a tricky statement. On an objective test, a person follows the thinking of the test maker, unravels a problem, makes a reasoned choice, or sometimes guesses; but he does not explain his train of reflective thinking, nor express any creative thought he may have had. Many have therefore never learned to think, nor to realize that they can think. Though accumulating a considerable amount of knowledge, most have never learned to write a good sentence nor to spell common words. *This is serious*, for as the school population is rising and schools will for some years continue to be overcrowded, there will be an increase in the use of objective tests. This means fewer essays and themes, less exposition, poorer reading, writing and spelling. The prospect is depressing.

5. *Incorrect Public Notices.* Too many signs are put up by ill-trained, near-literate or illiterate persons and by "the authorities". These engrave errors in young minds. Some notices have words which sound right when read aloud; some have letters interchanged (as are so many misspellings reported here); some have letters missing or wrongly duplicated; some have bad grammar. I recall huge painted letters in front of a school: "Shool–Driv Slo". It is almost impossible to convince an adolescent that such a sign, or the misspellings on a movie marquee are wrong, for advertisements are more respected than teachers.

6. *Carelessness and Laziness.* In spite of the impressive terminology in the textbooks, even the young people themselves admit that the school curricula do not challenge them. Mass education has become mis-education. "High School . . . (is) marked by academic non-competition. There isn't an area in which scholastic competition is practiced; even an honor roll is absent (16a)." Too lazy to think, the victim of social promotions, spoon-fed with diluted, superficial stuff, the school

graduate comes to college without practice in painstaking work, with no desire to do more than "get by", and with a sneering attitude towards learning for its own sake. When the work becomes hard, he is surprised to discover that he has never learned to study, but has caught over the years habits which are now a part of him.

7. *School Emphasis Is On Reading (Not Spelling).* According to Gray (22), the older emphasis in the teaching of reading was on the "mechanics of word recognition" and on reading aloud. Later, as the importance of silent reading and of comprehension was recognized, the purposes of reading instruction were increased, the terminology made more difficult and more inclusive and the technical inferences more refined. But the fact that numerous conferences were called—some with alarm—suggests that there were and are weaknesses in the theories, the newer methods, and the teachers who implement these ideas. In spite of these efforts, many still feel that the American people (and college students) are becoming poorer readers and poorer spellers. In as much as the give-and-take of communication demands spelling, one wonders why it has been disregarded.

8. *Reading Techniques Often Conflict With Ideas of Teaching Spelling.* Some methods in teaching reading suggest that spelling is a horrible scheme to delay the progress of the pupil who has reached the "readiness stage". Since pupils are taught to read whole words and to read for context and comprehension, they pay no regard to the syllables which make up the words, nor to the letters which make up the syllables. The experts claim that letters and syllables only delay reading, for the pupil sees a whole word and its configuration—not its letters. Results of this are the misspellings noted above, such as *acid* (asic), *animal* (aminal), *answer* (anser), *arm* (alm), *bulb* (blub), *brain* (brane), *comb* (cone), and *oil* (iol). Students taught to read by "the total communication process" indeed have no regard or respect for letters or syllables.

The logical next step in the "total communication" dictum is that one reads a phrase without seeing the words in it; then, a good reader reads a sentence without bothering with the phrases, and a paragraph without attention to sentences. Finally, perhaps, an expert reader "gets" a whole page without reading the paragraphs. Some college students carry this to an absurd conclusion and read their assignments without opening their books (24). "Current practice in the teaching of reading does not require a knowledge of letters" (4). Some experts suggest that the child need not know the alphabet,—and a few college students do not. No wonder they cannot use the index in a science book. A shocking, but revealing observation arose when a student was referred to an unabridged dictionary to look up *diarrhoea.* The student turned to the end of the dictionary, then after some minutes of fumbling lamely admitted that since he could not spell the word, he could not use the dictionary.

Flesch reports (11) that certain experts suggest that young readers play a kind of guessing game. A glance at the list published here shows that this game is a dangerous one. If these ideas thrive, our science will continue to deteriorate. College teachers can testify to this right now, and the data presented here strongly support this conclusion. Our poor speller does not see words correctly; his mental images of even familiar words are blurred, and as he often does not hear the words properly pronounced, and he has never really examined them (25), he "omits, adds or transposes letters, and . . . confuses one word with another (23)". No wonder the poor unfortunates have spelling, writing and reading difficulties, which make them unable to understand what they read or to express themselves well on paper. No wonder too they shun science courses like the plague.

9. *"Let's Go."* Everybody is in a hurry: even the instructor teaching a class to read. To give scope to all the phases of the modern curriculum, he cannot find enough time for drill, accuracy, neatness and the other "old fashioned" attributes; schools and colleges must now give a quick look and a superficial smattering. There is not enough time for "solid" knowledge; and there is little or no depth or mastery of subject matter.

This characteristic superficiality shows up when beginning students examine their own blood or an amoeba under the microscope or observe a hookworm or a tapeworm. Usually, after one brief glance and an "oh", the aver-

age student is satisfied. He sits back and lets the blood dry up, or allows the amoeba to creep away; yet he may have never seen these before. Only a few will patiently examine what they have, or will try to see more than the superficial or the minimum.

10. *Excessive Use of Visual, Audio-visual and Other Aids.* The phonograph, tape-recorder, sound film and television have played great roles in expanding the world. But these have at the same time decreased our spelling, writing and speaking abilities. We are becoming a nation of listeners and lookers-on. It is much easier to attend a "talkie" than to read a book. The silent movie challenged its audience to read; but television and the talking films "spoonfeed" the student so that, though he may hear a word often enough, he does not see it written or printed, nor does he need to write it.

A class viewed a film on peristalsis after covering the topic. The film explained the ideas excellently. The questions asked and the discussion that followed the screening proved the success of this audio-visual aid to instruction. But, when absent-mindedly, the teacher wrote "Peristalsis" on the blackboard, students asked to have the new word pronounced. One asked its meaning. Yet they had heard it many times and had themselves used it acceptably in the class discussion.

11. *Submission to the "Norm".* Writers of textbooks, committees of learned societies and teachers often allow the pressure of their environment, widespread but incorrect usages, pronunciations and queer accents to sway them. Some language texts even suggest that pupils should not be corrected for saying, "between you and I", "who do you want?" nor for spelling words such as "thoro", "thru" and the like. Comic books and popular literature carry such words as "Keerect", "Sez-you", "okay". If we are to educate, we must, in the words of St. Paul, *transform* rather than *conform* to the popular.

When Kinsey and his colleagues reported findings on the behavior of the human male (14) and female (15), many readers, failing to recognize the factual reports of the *status quo* in samples of the population, criticized the researchers for popularizing evil. Others used the findings to justify their actions. *Ipso facto,* popular usage, even in as living a thing as a spoken language, should not be accepted as correct, merely because it is widespread. "Sin" is perhaps the most common of human experiences, but Christian standards, ethics and ideals must never be lowered. So with the standards of language and spelling: teachers must accept and respect these standards and instruct their pupils accordingly.

Thorsten Veblen (1857-1929) in his "Theory of the Leisure Class" blasted conventional spelling as "archaic, cumbrous, and ineffective; its acquisition consumes much time and effort;" but in the same book he honors spelling as a "mark of respectability," and admits that "failure to acquire this (badge of culture) is easy of detection." Veblen himself, in all his writing, did not digress from conventional spelling.

12. *Cheating.* Concerned teachers note with distress the spread of classroom cheating. There is no longer much value to an honor system. Teachers wink at cheating and remark that the pupil needs help anyway. Writers of textbooks apparently accept cheating, the use of "ponies," and the theft and sale of examination questions as inevitable as taxes and death. They throw up their hands and do little to stop the trend. If a child is asked to spell a word, he looks up while a classmate finds the word and whispers it. If a student refuses to give help in an examination, he has a hard time with his fellows. Some pupils will brazenly read answers from an open book during recitation, and most teachers now accept the situation in despair or with a shrug of indifference.

13. *Poorly Paid, Poorly Prepared, Uninspiring Or Disinterested Teachers.* Many teachers today have not themselves learned to spell some common words, and so must accept whatever the pupil says; some cover up ignorance by advising: "Say Jerusalem and go on." Thus schools become bureaux of misinformation. Atkinson (1) reports that a mother withdrew her child from the seventh grade when she discovered that the teacher had barely finished the fifth grade.

14. *Loss of Interest in Letter Writing.* (12). New, dramatic ways of communication have made writing less popular than ever. One is advised not to write but to telegraph. Al-

most any store offers cards with messages already printed. All one needs to do is mark crosses in the appropriate squares, and sign. Birthday and holiday greetings can be telegraphed by index numbers, and instead of the cordial, personal, handwritten "bread-and-butter note," one can now send a pretty, printed "thank you" card.

One solution seems to be that schools must get pupils to write more letters, more essays, more themes. Teachers must be willing to read through pages of "stuff", so as to help students learn to spell correctly and to express themselves.

Inferences

As a basic part of communication, spelling is important. "Poor spelling is the defect most frequently noted in so-called educated persons." (9). The person who is uninterested in spelling, and treats it only as an educational achievement or a social attribute, becomes violently critical of the schools if he finds that the bad speller is his secretary, his typist, his child or some member of a group doing work which has to be seen by the public.

Spelling *is* important and the evidence presented here shows that our spelling situation is deplorable.

Spelling and reading are essential to communication, but as now taught in the schools, have unfavorable influences on the teaching of science in the colleges. It seems that even though this is an Age of Science and Technology, *the schools develop a fear of science in young people by the way they offer instruction in communication.* Educators have pointed out that the number of pupils attracted to science is not enough to supply today's needs and will soon fall below tomorrow's requirements. The bad situation is worsened when high school graduates come to college with the serious deficiencies they now have. They are frightened away from science. College teachers of science must therefore take the responsibility "for the recruitment and preparation of the high school teachers of science (2)"; they must take the initiative in attracting youngsters to the field of science. These tasks they must do if our supply of scientists and technologists is not to dry up; these they must do, if America is to remain strong and free.

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Research by the High School Student

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If he does not know it before, the science student in high school should learn the difference between demonstration experiments and research experiments, and between searching for something in the library and doing research work.

We had some mud-dauber nests on the laboratory table—a few students and I. Eagerly we opened one cell, then another cell, to observe the contents.

In some the mud-wasp egg had not hatched, so its store of food (from five to nine paralyzed spiders) which was left there for the growing larva was still in the cell. In others the fat flabby white legless larva was almost crowding the space. Before long this would have become a darting wasp, carrying little pellets of mud in her mouth to build a nest on the roof of some boathouse or barn to store the eggs and food for the hatching larva, completing the life history.

Arthur Nepstad asked, "How do they get legs and wings and eyes?"

"These develop after they eat the stored food," I answered glibly.

"I'd like to see that happen," Arthur persisted.

"We can break open a new chamber from time to time and see the progress. But if the pupa is left exposed it will dry up."

Arthur thought a bit, then made this thoroughly original suggestion, "Why not put some of them into medicine capsules so we can watch whatever happens?"

I said, "I think that is a wonderful idea! Why not? Why didn't I think of it!"

So we did just that and punched three needle holes in the end of each capsule. Into the capsules went one fat larva of a mud-wasp—one which had already eaten its supply of spiders. Each capsule was given a number in ink, for each grub must have a separate record in notes and drawings. The capsules were kept in a small box, on corrugated white paper. The box provided the darkness of the original cell.

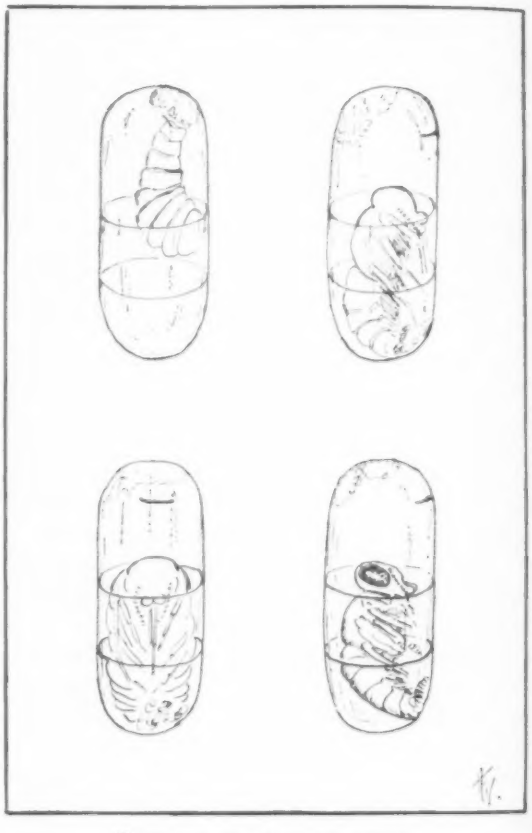

Figure 1. Leaf-cutter pupae.

Arthur said, "Let's try it with the leaf-cutter bees, too." We had a few of their leafy capsules which had been found in a boring in a tree trunk. We kept some of these as they were. From others we peeled off the layers of leaf-ovals until we found the white larva in each. These were also placed in medicine capsules.

We watched and made records in writing and in drawings.

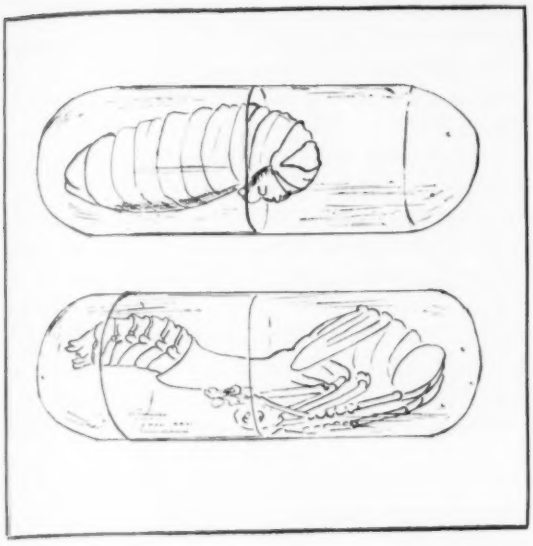

Figure 2. Mud-wasp larva developing into a pupa.

All of this I call research. Arthur's idea was original. It was exciting because it came from a questioning young mind, challenging because no one, so far as we know, had ever thought of doing it before. For when I queried Phil Rau of Kirkwood, Missouri, naturalist and bee specialist and T. D. A. Cockerell of Boulder, Colorado, another authority on wild bees, neither one had thought to try it. I recall Phil Rau's comment, after expressing pleased surprise at the suggestion, "I think I'll try it on some of my pets."

Frequently we hear someone in a library say, "I'm doing some research for a club paper." Perhaps. Probably she is merely searching for some material and is reading and taking notes on this.

Arthur's experiment is an example of simple research.

It is unnecessary, I suppose, to tell you that the dear little larvae fooled us. Whatever took place took place beneath that white outer "skin" which one day split to leave the pupa exposed—with its legs, crumpled wings, great eyes, and antennae already developed. The wings, of course, were to be inflated later. But every part was there.

Still we learned much. We learned how to carry on a simple research problem, which is "systematic investigation into a subject in order to *discover* facts or principles."

The Parasitic Worms In High School Biology

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Introduction:

One of the most fascinating units in High School Biology is the study of the parasitic worms. In an effort to make this topic worth while and practical we devised a unit plan for the teaching of parasitic worms which proved both instructive and interesting as a teaching device in the biology laboratory and classroom.

Aims and objectives:

1. To study the parasitic worms from the standpoint of structures, prevention, disease causes, symptoms, carriers, and relation to public health.

2. To understand practical methods of prevention of these infections in our home community.

3. To indicate the functions and duties of the local, state, and federal public health agencies, in endoparasitic control.

4. To compare the so-called worms, with other animals studied.

5. To arouse appreciation for the keenest of observation of the ancient Hebrews in relation to what we now know to be infestation with trichina; respect for their ability to single out the swine as a transmitter of an illness; respect for their rulers who incorporated the knowledge in the priestly code of laws (Leviticus 11-7 & 8, 34 & 35).

6. To show that swine, as a vector or a transmitter of trichinosis is dependent upon the invention and improvement of such aids as the microscope and also upon modern research techniques in cutting and staining thin sections.

7. To stress in recitation periods, modern methods in animal husbandry; the prevention of the spread of trichinosis in swine is partially dependent upon the use of rat-free quarters (commonly known as hog pens). Hogs will eat rats if hungry. The rat is one of the intermediate hosts of the trichina. The

thorough cooking of any garbage, containing scraps of meat, and fed to hogs, is important prophylaxis.

Unit 1. Tapeworm

The Platyhelminthes, flatworms, include the *Taenia solium*, pork tapeworm, and the *Taenia saginata*, the beef tapeworm, and the liver flukes. The commonest length is 15 to 30 feet with up to 1,000 proglotids or segments. The scolex or head contains suckers only. The distribution is world wide, the cysts being found in the muscle of beef and dairy cattle, or hogs. The final host is the intestine of man. The tapeworm cycle is as follows: cattle eat grass and hay, etc., infected with tapeworm eggs; the eggs form from larvae which lose their intestinal membrane and travel to some muscle destination. Here they form a bladder worm or cyst. The *Cysticircus bovis*, are small white ovid bodies commonly called cysts in beef muscle.

If infected meat is improperly cooked, black market or uninspected meat is eaten the cyst is carried into the human intestinal tract. Here the worm turns right side out, and the cyst is digested and finally attaches itself to the walls of the intestine. Infestation symptoms are capricious appetite, loss of weight, restlessness, occasional fits, and sometimes anemia.

The diagnosis is as follows: the mature worm passes thousands of eggs from mature proglotids which may be found on microscope examination. Sometimes the proglotids themselves are passed off with the excreta. The *Talnia solium*: hog tapeworm cycle is similar to the beef form except the intermediate host is the hog. Cysts are small bladders called pork measles. This tapeworm has hooks and suckers both on the Scolex.

The prevention is a sanitary sewage disposal, veterinary inspection, U. S. State or City (limitations), and thorough cooking of meat.

The Hebrews and Mohammedans regard eating pork as a religious sin, which is today valid as an endoparasitic prophylactic procedure. (Deuteronomy 14:8).

Unit 2. The Liver Flukes

The Flukes include the Distomata, Trematodes and *Fasciola hepaticum*. The complex but interesting liver fluke cycle may be drawn on the blackboard and labeled, or illustrated with diagrammatic wall charts. This infection is important to live stock raisers of cattle and sheep.

Sheep with liver flukes in their liver shed thousands of eggs from feces or urine, which if they fall in water, the cycle may go on. The eggs change to free swimming miracidia (look like paramecium or ciliated epithelium) which must find a snail host. Miracidia are ingested by the snail or pass through the skin to the snail's liver. Here it changes to a free swimming cercariae where it emerges and swims to encyst itself on grass or water cress. If water cress is ingested and is eaten by sheep the cycle is continued. Man may also be infected with distomiasis by eating parasitized water cress.

In the Chinese liver fluke, the Miracidium can give rise to 10,000 cercaria. Human feces contain eggs, which emerge as a Miracidium and swim free in the water. Water snails pick up the redis stage, a sexual stage. Then the cercaria stage follows to be ingested by fish. Man eats raw fish (adult) and so becomes infested.

To prevent sheep liver fluke from reaching man, we avoid infected water cress, require meat inspection to locate flukes in sheep, and recommend final thorough cooking of sheep livers. The common symptoms of distomiasis is jaundice, due to the clogging of bile ducts with flukes; the membranes, blood and skin taking on a yellowish discoloration.

Schistosomes are widespread in the tropics (Philippines) and was a medical problem in General MacArthur's Pacific island hopping campaign. This is the flat worm that upset an Egyptain dynasty. It can enter the body through drinking water, skin bathing, and food washed in infected water. The disease caused by it is Schistosomiasis.

Unit 3. Nemahelminthes (Round-worms) Trichinosis

The cycle of *Trichinia spiralis* starts when hogs or rats eat garbage infected with the trichinia. The ova pass into the hog's intestine where the larvae penetrate the walls of the intestine and enter mesenteric capillaries. They them move through the circulatory system to voluntary muscles, and there en-

cyst themselves. Severe myositis that does not respond to the ordinary treatments results. The symptoms resemble rheumatism with severe muscular pain. Should humans eat uncooked or uninspected pork which is trichinosed, there is a direct worm transmission to human subjects. The cysts are lost in digestive fluids, but the worms pass via intestines directly into human muscles where they encyst themselves. There is no treatment as no medicine can penetrate the cysts lodged in muscles. The disease can, however, be prevented by cooking, and inspection of pork, and raising hogs hygienically, observing sanitary preventive measures.

Necator Americanus (*Hookworm*)

How can we prevent hookworm infestation as typified by characters in *Tobacco Road*, *Little Abner's Dog Patch*, *Poor Whites*, *Share Croppers*, and *Migrant Workers?*

The cycle is started when eggs are dropped by hogs, humans and dogs, infected with the necator in the intestines and dropped on grass or weed plants. Humans may walk bare foot in infected grass, like Ma Abner. The eggs change to pointed larvae which penetrate the skin causing a local itch. The larvae then pass into the human blood stream and enter the pulmonary circulation to areoli (air sacs in the lungs) and cause damage to the lungs or sometimes tuberculosis. The larvae are then coughed up to the mouth and swallowed. They enter the intestines of the human and hook to the intestinal wall where they cause anemia, chronic exhaustion, and diarrhea. This disease affected the course of the Civil War as a high percentage of Southern troops according to medical records were infected with hookworm. World wide distribution is placed at 15,000,000 cases. The treatment is tetrachloroethylene or thymol, etc., given on an empty stomach. The prevention consists of cleaning up infection in hogs and dogs, treating all human cases, and building and maintaining sewage disposal and filtration plants.

The Filaria (*Wurcheria bancrofti*)

Have you ever heard of elephantiasis? It may be a symptom of Microfilarias which in the United States is found only in Charleston, S. C. Man is the definitive host of the Microfilaria in the blood stream.

The carriers are the Anopheles, *Adedes egypti*, and Culex mosquitoes. The mosquito bites a person and the Microfilaria penetrates the skin. The worms may block lymph vessels causing elephantiasis, anemia, clogging up of the heart, and the valves so that death results.

The prevention of Filariasis is mosquito control, and sanitation. Microscopic tests of possible infected persons are made looking for filaria in the blood. Antimony and bismuth salts are used in treatment.

The Ascarid Worms

Ascaris lumbricoides is from one to twenty inches long. Two hundred thousand eggs may be laid daily from each female, and pass into the ground from the hog, dog, or human hosts.

The Ascarids mature in human intestines. Inside the egg shell a small worm develops. If the ova are swallowed from roots or stems or leafy foods, they pass into and develop in the human intestine, where they burrow to enter the blood vessels, lungs, air sacs, to lodge in the intestine or coughed up into the mouth. Usually no symptoms are in evidence, but children may show symptoms of nervousness.

Prevention is sanitary disposal of feces. Infestation are usually due to eating fresh vegetables from soil contaminated with human feces. The habitat, Ascaris is common in the Southern United States. Hog ascarids do not infect humans and vice versa. Diagnosis is made by finding the ova in feces on microscopic examination.

Student Projects

1. You are a public health official in a Southern state. What (and why) would you tell people to do to prevent tapeworm and Ascarid hookworm?
2. What can you do as a housewife to prevent tapeworm and Trichinosis infestation in your family.
3. What is the first line of defense against most flat or round worm diseases?

There are bright prospects that American farmers will be able to grow and harvest "cortisone crops" from certain plants—which would mean plentiful, less expensive hormones for medical use.

An Experimental Approach in Teaching Elementary Botany

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"In Botany 1 this semester, we shall have no textbook, no laboratory manual, and no formal lectures by the professor." This announcement, made to a freshman class in elementary botany resulted in raised eyebrows, not only in the class but also among some of the professors who heard the announcement. Now that the course has been completed, and some attempt at evaluation has been made, the story might interest those who are faced with teaching science to freshman classes.

The course had been taught for five years in the traditional manner, with two lectures and a three hour laboratory period each week. There were several students' comments which stimulated reorganization of the course. The comments were perfectly ordinary, and stimulating more in their implication than in the questions themselves. Such remarks as, "Is this what I am supposed to see?" "How many petals is this flower supposed to have?", seemed to imply that the students were afraid to trust their own observations.

I suddenly recalled a class in high school physics that I had once observed. The teacher was demonstrating the electromotive series, using a jar of electrolyte on his table, a series of metallic electrodes, and a huge voltmeter that could be read easily by all the students. The metals were introduced into the bath, and the class read the voltage from the meter and entered the reading in their notebooks. This went along very nicely until, in one demonstration, the meter read 1.9 volts. The teacher checked the metals, washed them off, and returned them to the bath—still 1.9 volts registered on the voltmeter. The teacher was obviously disturbed, and finally announced that the reading should have been 1.1 volts, whereupon the students immediately erased the 1.9 and dutifully wrote in the 1.1 value. My thought at the time was, "Is *this* teaching *science*? Here are these students being taught to overlook the evidence of their own senses in favor of the authoritative dictum of the teacher. Is this scientific?"

My thoughts reverted to our own Botany class, and I found that in lecture, and even in the laboratory, the students were depending more upon the utterings of their instructors than upon the materials presented. I was rather horrified to find out that my criticism of the high school physics teacher applied also to myself. The question was, how could the students be introduced to botany on a basis of lab work? Could we build up a basic background in botany founded upon the students' experiences in lab? To do so would involve study of plant materials without prejudice on the part of the student, so that sources of prejudice should be eliminated as far as possible. It was felt that the main sources of such prejudice were the text, laboratory manual, and the lectures, since each of these gave the student an idea of what to expect. The idea of offering a freshman course without a text, lab manual, or lectures seemed appalling unless some sort of continuity could be introduced into the laboratory

It was thought that if a long-term problem were presented to the students, the step by step attack on the problem would give continuity to the course. With this hope in mind, we drew a deep breath, and launched out into our experimental approach.

The First Class Meeting

The following notes were used for the first "lecture".

1. The course this year is new in organization; in method; in laboratory; and in examination.
2. There will be no formal lectures, unless

the class at some time specifically requests a lecture upon some definite topic. Such lectures may be delivered by the professor, or by appointed members of the class, as a symposium.

3. There is no assigned textbook for the course, and no laboratory manual. There are, however, many books on botany, both elementary and advanced, in the Biology Library. These are *not* on reserve, you may select any book that you wish for references.

   May I point out at this time that there is no such thing as an accurate text. Botany is advancing so rapidly as a science that it is impossible for an elementary text to be up-to-date in all fields. Even if it were up-to-date when written, it would be partially out of date when published. Therefore, WE SHALL NOT USE ANY TEXT AS AN AUTHORITY FOR ANY OF OUR CONCLUSIONS. Our conclusions *must* be based upon our observations in the laboratory. Books may serve well as a source of *ideas*, but let us not use them as a source of *facts*. These come from the plants studied in the laboratory.

4. The organization of the course is YOURS. YOU will decide what we will study, and when we will study it, BUT:
   You will be held for a knowledge of the structure and function of seed plants, and at the end of the semester you will be expected to know quite a bit about plants, how they are constructed and how they function.

5. Here, basically, is your problem: We have here on display a series of bean plants of varying ages. (The display included seeds; seeds with root emerging; seedlings with cotyledons emerging; seedlings with first leaves; seedlings with compound leaves; plants in flower.)

   If we take this bean, and plant it, we find that this whole plant, complete with flowers, develops. Your problem is: "What has occurred in the meantime? How did these various parts, root, stem, leaves, flower, develop? Where did they come from, and just how are they formed?"

6. You will be supplied with laboratory equipment, with some plants, and with greenhouse space where you may grow plants that you wish to study. You will decide what investigations you wish to pursue. I will attempt to act as moderator in your discussions, and will help you, BUT NOT DIRECT YOU, in setting up your investigations. My major role will be to ask questions, which you can answer from your observations. I am *not* an authority, but the plants which you study *are*. The facts lie with the plants, not with what I say about them.

7. You will be working in groups of about six, around a lab table. You are expected to pool your findings with other members of the group, and in cases of disagreement, call in the other groups for consultation. If the disagreement continues, there is no point in calling *me* in to decide the case, because your conclusions must be based upon *your observations*, not upon *my opinion*.

   Naturally, you will find cases which cannot be resolved with the materials at hand. Such cases must be investigated through the use of more material, or must be left unresolved for the moment. We cannot hope to solve all of the questions which will arise during the course.

8. During the regularly scheduled laboratory periods, we shall attempt to pool the findings of the table groups in both laboratory sections, to see if we can draw reasonable conclusions therefrom. We shall also attempt to develop methods of approach to be used in the coming lab period, so that you will know what to do, and how to do it.

   These will be discussion periods, with your professor acting as moderator. The responsibility is *yours* to share your findings with the other groups, and to see that they share their findings with you. You may ask them direct questions if needed. Now, are there any questions?

   Q. 1. "Who will decide what plants we can grow?"

   A. "You will, and you will be held responsible for such plants as you do grow. If, for example, you grow orchids, gardenias, or roses, in addition to other plants, you will be held for the variations in structure shown by these plants."

Q. 2. "How about examinations?"

A. "At the present time, I do not know, but I think that I shall be able to call each of you into my office during a regularly scheduled lab period, and can have a conversation on what you have learned during the course."

Q. 3. "The bookstore is selling a text for this course. Why?"

A. "The text is demanded in the other lecture section. You may purchase one if you desire. The reason no text is required here is that I do not want you to go into the laboratory with a preconceived idea as to what you are going to see. In short, read the books for IDEAS, not for FACTS."

This concluded the first meeting of the class, and they proceeded to the laboratory, where seeds and seedlings of both castor bean and garden bean were available. The following questions were presented to give starting points for observations:

1. What is the order of development of the various parts of the plant?
2. What similarities and differences can you observe in these two sets of plants?
3. What structures in the garden bean seed correspond to those of the castor bean seed?
4. How many of the structures of the grown plant are distinguishable in the seed of the plant?

The students varied in their reaction. About fifty percent wondered what they should do, but gradually the two groups (at two tables) settled down, one to a strictly comparative approach, the other to a developmental approach.

The comparative approach group even sectioned the stems, and found that the epicotyl of the garden bean was hollow, whereas the hypocotyl and all of the castor bean steam was solid. They reasoned that the hollowness of the stem was due to increase in diameter caused by growth, and all accepted this until one of the students measured the diameter of a young (hollow) epicotyl and found that it was less than that of the older, solid hypocotyl. The reason for the hollowness was left in abeyance, but the FACT was noted.

The developmental group traced all of the features usually "taught" in the seed, and noticed the reduction in size of both the endosperm of the castor bean and the cotyledons of the garden bean, as the seedlings developed. In the second lab section this was carried further in an attempt to homologize the structures in the two seeds. The discussion as to whether the cotyledons of the garden bean were homologous to the cotyledons or to the endosperm of the castor bean, was carried well past the closing hour of the lab.

The entire class participated in this closing discussion. Dissection after dissection was made (excellently, too!), while the remainder of the class and the professor watched. As the dissections were made, the facts were pointed out, and at the close of the period it was accepted that the endosperm of the castor bean was "attached" to the "leaf," and that in the garden bean the "cotyledon" was attached to the stem.

Although the class was unselected, the initiative that they demonstrated was quite surprising. They reasoned, during a lecture period, that the growth of the root from the radicle had to be due to either the enlargement of cells already present, or to the increase in number of cells. Thus, in a later lab, they took young roots of onion, cut them into six pieces, and gave one portion to each member of their table group. Each student cut up and stained his portion in iron aceto-carmine, and then they pooled their findings to discover that the higher portions had longer and wider cells, and only the lowest portion (the root tip) showed evidence of cell division. In the next lab period, each student studied squashes of root tips in aceto-carmine. They noticed the changes occurring in the nucleus, and drew the configurations which they could observe. These drawings they arranged in order on the wall of the laboratory, in a sequence proceeding from one cell to two cells. The final series of drawings was an excellent presentation of the process of mitosis. Of course they did not learn the terms for the various "phases" of mitosis, but they did demonstrate an understanding of the process. Their presentation of some two dozen transitional stages on the wall of the labora-

tory emphasized their concept of cell division as a continuous process.

At the beginning of the course, we felt that the students would cover less material, might cover it less intensively, but should retain more of what they learned. Experience has shown us that the students actually cover more material, cover it more intensively, and appear to retain it more effectively. Also, since the students are actively engaged in working out their own problems, they are more interested in the materials before them. Probably the strongest criticism, mentioned by less than 10% of the class, was that they felt that they were not covering enough material. However, this feeling was not borne out by their achievement in tests. The most frequent favorable comments by the students were, in order: (1) the experimental approach was highly desirable; (2) the approach was interesting; (3) it was a stimulant to learn more, not only in botany but in other fields, using the same approach.

The course has been offered following this method five times, and will, I presume continue to be offered along these lines. Although the procedure is far more demanding of the instructor's time and thought than is the conventional teaching method, the instructor profits from having greater stimulation from a more inquisitive group of real students.

Eye Care Pamphlet

A blind worker waits at an intersection. A young man assists him across the street.

"I'm new at this," the blind man says. "Lost my sight six months ago. Some chemicals exploded in the factory where I worked—right in my face."

These words are from the introductory paragraphs of a 28-page pamphlet entitled "Save Your Sight" published by the Public Affairs Committee in cooperation with the National Society for the Prevention of Blindness. The pamphlet is being offered at 25 cents per single copy by the National Society, 1790 Broadway, New York 19, N. Y. to increase public awareness of the need for eye care.

Two cups of heavily roasted coffee contain your daily requirement of the vitamin niacin. Most of the niacin in roasted coffee is formed during roasting, and at least some of it appears to be made from a related compound, trigonelline, which has no vitamin activity. The niacin is easily dissolved out of the ground coffee during preparation.

Biology in the News

BROTHER H. CHARLES, F.S.C.
Saint Mary's College
Winona, Minnesota

A KILLER OF MEN, Frank C. Hibben, Outdoor Life, March, 1957, pp. 45-47, 77-79.

This account of tracking a sloth bear which had become dangerous to a small area in India contains many ideas of the conditions existing in another part of the world.

LIVING MYSTERIES OF THE DEEP, Daniel P. Mannix, Saturday Evening Post, March 9, 1957, pp. 24-25, 109-119.

Collecting rare and interesting animals from the sea is profitable for talented skin divers.

AMERICA'S NEWEST WILD ANIMAL, William Byron Mowery, Saturday Evening Post, March 16, 1957, pp. 51, 137-141.

The coydog, or brush wolf, a hybrid between the coyote and the dog, is our newest and wildest predator. It is gradually increasing and may replace the coyote in many regions.

CHILDHOOD'S NO. 1 ENEMY, L. Emmett Holt, Jr., M.D., Good Housekeeping, March, 1957, pp. 34-35, 131.

Over 12,000 people died as a result of accidents during the past year. This article suggests means which parents and others can take to prevent accidents. A good article to stimulate safety campaign.

91 POUNDS OFF, Dawn Crowell Norman, Ladies Home Journal, March, 1957, pp. 80-89.

Excess poundage is a social as well as a physical hazard. Excellent material to initiate a discussion on dieting.

THESE 7 PEOPLE WERE SAVED FROM CANCER, Patricia and Ron Deutsch, Ladies Home Journal, March, 1957, pp. 128-129, 231-232.

Sane notions about diseases, which can be acquired in early life, brought these people to the doctors in time.

Teaching About Predatory Birds

RICHARD F. TRUMP
Senior High School
Ames, Iowa

"A chicken hawk is any big bird that you can shoot but can't identify." That's how one of my students defined a term that wasn't in the glossary of his biology text. As a matter of fact, he found very little in any text about any predatory bird.

Then why teach such a unit? Because this is a controversial topic with a right and wrong answer . . . Because it gives students an opportunity to evaluate a variety or sources of information . . . Because it encourages students to weigh evidence and reach their own conclusions . . . Because the study of predation is a vivid lesson in how nature works.

Some years ago I approached this unit with a crusader's zeal. I lectured, showed pictures, provided the right literature. But besides bringing my own prejudices into sharper focus, this approach denied the students the richest reward education has to offer. It denied them the responsibility for making up their own minds.

So my viewpoint has changed. It may continue to change. But, for whatever it may be worth, this is the present work pattern:

1. Brief preview discussion, so students will know what we mean by predatory bird.
2. A quick "straw vote": Should the number of hawks and owls be increased, decreased, or left about the same?
3. A period's general reading—magazines, books, pamphlets; even the ads of ammunition companies.
4. A quick check to see if anyone would like to change his original vote. If it hasn't already been mentioned, someone is sure to press this point: We can't vote fairly on all predatory birds as a group: different kinds have different habits. This leads naturally to a discussion of what we need to know about predatory birds: How do biologists learn about their food habits? How does predation affect the populations of prey species? etc.
5. Study duplicated information adapted from "What's a Hawk?", The Iowa Conservationist, Vol. 2, No. 10.
6. Discuss identification of Iowa hawks. Life-size tracings on blackboard are helpful. Peterson's FIELD GUIDE TO THE BIRDS has a plate which can be projected with a baloptican to obtain outlines. Descriptions are confined to distinctive "earmarks."
7. Same for Iowa owls.
8. More general reading on predation.
9. Class conclusions. With some groups I have found it effective to let a student act as a judge, others as witnesses and jury.
10. Review of important points—an opportunity, if I haven't had one already, to sum up my own opinions. Incidentally, I offer them as *opinions*, not as edicts.

The outcome? It is hard to measure thoughts and attitudes. And it might be uncomfortable for us teachers if we could. But some of the outcomes are apparent in the way students talk. I think it would be helpful to try recording a typical segment of discussion:

Bill: I don't see why the marsh hawk is protected around here. Look at all the birds it eats!

Gene: Yeah, and rabbits too.

Bruce: Sure, but it eats rats too. And field mice. Those four mouse skulls in the show case all came from one marsh hawk, didn't they?

Bill: Maybe so, but what does that prove? The same hawk maybe ate four birds the day before.

Katherine: How can a hawk kill a rabbit?

Jim: If there's anything wrong with the law, it's with the great horned owl? What's so bad about it?

Instructor: Hold everything—one question at a time. Let's go back to Bill's comment.

A resident in Ames High's biology lab for six weeks, this Screech Owl was caught in a garage by student Bernadine Sifrit. It had complete freedom in the lab. In daytime it lived in this hollow log section on top of a book case. At night it frequently perched on the head of a stuffed bald eagle. Photo by Richard Trump.

Ready for take-off, this Red-tailed Hawk is wearing a numbered leg band furnished by the Fish and Wildlife Service to licensed bird-banders. This one was banded by the author near Keokuk. Photo by Richard Trump.

He said the marsh hawk may eat birds one day but mice the next. How do we *know* what they eat?

Janice: By finding what's in their gizzards.

Katherine: Oooh!

Instructor: Is that right, Marcia—look in their gizzards?

Marcia: That's what a pamphlet said. But it sounds like a wasteful method. Can't you find out what they eat by just watching them?

Ron: It takes too long. What's wrong with gizzards?

Marcia: You have to kill the bird to find out if it's bad.

Bill: Maybe it eats something different every day.

Ron: What if it does? The Department of Agriculture gets whole scads of specimans, and if you average everything together you have a pretty good idea what the bird really eats over a period of time.

A better way to know what a hawk or owl eats is to study the bones and feathers that it regurgitates as pellets. But the real trouble is that even if you know what a bird eats, you still may not know what it *kills*. Maybe it's a scavenger and eats rabbits that are killed along the highway or chickens that die of disease.

Instructor: Then the bird-watching expedition Marcia was recommending would help decide the issue . . . .

Marcia: Did I say that?

Instructor: Well, if biologists get out and and really see the birds, they'll know if the predators are killing their own food or finding it already dead. If we depended on stomach and pellet analysis alone, we wouldn't know much about the economic status of the bald eagle or turkey vulture or several other birds.

Jerry: Is a turkey vulture the same as a turkey buzzard? My uncle was telling me about a buzzard nest in a hollow stump . . . Et cetera—with many detours.

Even sturdy individuals who don't like to admit they've changed their minds are likely

to be swayed by general agreement of the class. And such discussions with a little guidance, actually do reach a consensus. That is why I say that some of the outcomes are apparent in the discussions. Here are other ideas that are generally highlighted by student participation:

There's a general notion that the bigger the predator the bigger the prey. That's not altogether true. Look at the quantity of insects eaten by the big red-shouldered hawk. Then look at the larger proportion of birds taken by the much smaller sharp-shinned hawk.

In general, the larger, slower hawks are the most valuable. But they are also the easiest to shoot.

Predators eat mostly the animals that are easiest to catch, which generally means the foods that are most abundant. This is important to man's interests: When pests are abundant, that's when we most need pest control; when a valuable game bird is abundant, that's when we can best afford to spare some of them. Students are amused by the thought that man is much the opposite of wild predators in this respect. He often grabs for the things that are hardest to get. Social pressure convinces him that the rarest and most expensive items are best.

As one wit put it, "An owl that is finding plenty of rats doesn't care a hoot if rats happen to be cheap." Incidentally, investigations have shown that fluctuations in the diets of predators are a pretty good indication of the relative abundance of the prey species. Actually, of course, these fluctuations indicate changes in the *vulnerability* of the prey. And this is determined not by abundance alone but also by protective cover and related factors.

Here is another way in which predators affect man's interests. In any given area, the more food there is the more predators there will be to eat it. This is partly because the birds move into areas where they find plenty to eat. Another reason is that where food is plentiful, larger families of predators are matured. A long-eared owl, for example, starts incubating when the first egg is laid. The remaining eggs are laid on about alternate days, so the clutch is a complete week or two after incubation started for the first egg. That means a wide discrepancy in age

Great-horned owl, reared from the fluffy stage by biology students Don Bappe and Paul Mumm, was a frequent visitor at Ames High. Interest in predatory birds is sharpened by having live specimens available. Photo by Richard Trump.

and size of the owlets. Now if there is plenty of food, this discrepancy may be unimportant. But if there is a shortage of food, some of the younger owls may not survive. That's one way in which nature adjusts the predator population to suit variations in food supplies.

One year as a class project we sent an inquiry to the conservation departments of each of the states and a number of Canadian provinces. We asked about their laws concerning predators, whether their laws were based on any special investigation of their predators, and what experience they had had with attempts at control. The responses are a valuable reference source for the more aggressive students. For class use, some of their pertinent excerpts were duplicated.

Audubon Magazine has since published an excellent article that reviews the legal status of predatory birds. It is by Richard Stuart Phillips. "A Fair Deal for our Birds of Prey?" in the Nov.-Dec. 1949 issue. While referring to sources of information, I want to mention some of the reference material we use for this unit. The magazine articles include Natural

Business end of a Great Horned Owl is the feet rather than the bill. This is a "winged" specimen found by students who were hunting pheasants near Ames. These owls frequently smell of skunk—one of their food species. Photo by Richard Trump.

History Magazine, Outdoor America, Nature Magazine, Audubon Magazine, Field and Stream, Outdoor Life, National Geographic, and Iowa Conservationist. We have several U.S.D.A. bulletins and Common Hawks and Owls of Iowa, published by the Extension Service, Iowa State College. Most valuable of the books on our shelves is Bent's Life Histories of the Birds of Prey published by the Smithsonian Institution; unfortunately this is out of print. Then we have a number of leaflets and reprints obtained from the National Audubon Society. Students are of course helpful in locating new material—especially in the sports magazines.

In listing our work pattern for this unit I may have given the impression that our sequence of topics is tightly mapped out in advance. It really isn't. And the sequence is likely to be interrupted when Jack brings a pet horned owl, or someone finds a hawk carcass displayed on a roadside fence. We examine the digestive tract of any fresh specimen. One red-tailed hawk, for example, contained only the bill, feet, and gizzard of a junco. The junco's gizzard, incidentally contained a number of weed seeds which germinated when we transferred them to a flower pot.

I said there is a right and a wrong answer to the predator question. This, I believe, is it: Campaigns for eliminating predatory birds are both poor economy and poor ecology. We *need* predatory birds. And while very few species are beneficial enough to deserve absolute protection, no species is bad enough to deserve general persecution.

Books for Biologists

PERCEPTUALISTIC THEORY OF KNOWLEDGE, Peter Fireman, 50 pp., $2.75, Philosophical Library, New York, New York, 1954.

Perception, thinking, and logic are three basic mental activities, always interwoven and jointly lend themselves to the building of a perceptual view of the world and to the formation of a perceptual theory of knowledge.

ON THE NATURE OF MAN, Dagobert D. Runes, 105 pp., $3.00, Philosophical Library, New York, New York, 1956.

This new work is offered as an attempt to define the border lines of human thinking and human morality. This type of soul-searching philosophy is sometimes baffling, frequently of melancholy character, but always fascinating and inspiring.

DICTIONARY OF ANTHROPOLOGY, Charles Winick, $10, 579 pp., Philosophical Library, New York, New York, 1956.

This book is the only collection in any language of the specialized vocabularies of all the fields of anthropology. It includes approximately 10,000 entries from archaeology, cultural anthropology linguistics and physical anthropology. Many terms hitherto used on the basis of a tacit consensus about their meanings and a supposedly shared notion of their connotations are here defined explicitly for the first time.

PSYCHOLOGY—GENERAL, INDUSTRIAL, SOCIAL, John Menro Fraser, M.A., $7.50, 310 pp., Philosophical Library, New York, New York, 1956.

The author has in this volume surveyed the fields of general, industrial and social psychology from the manager's point of view and drawn the main issues together. Detail has been disregarded in order to present a coherent theme.

THE WORLD OF BEES, Gilbert Nixon, 214 pp., $4.75, Philosophical Library, New York, New York, 1955.

Bees have been a source of interest since ancient times. In this book Mr. Nixon has tried to give the reader a glimpse of the whole world of bees in all their intriguing diversity of habit and behavior.

(Continued on page 157)

Correction

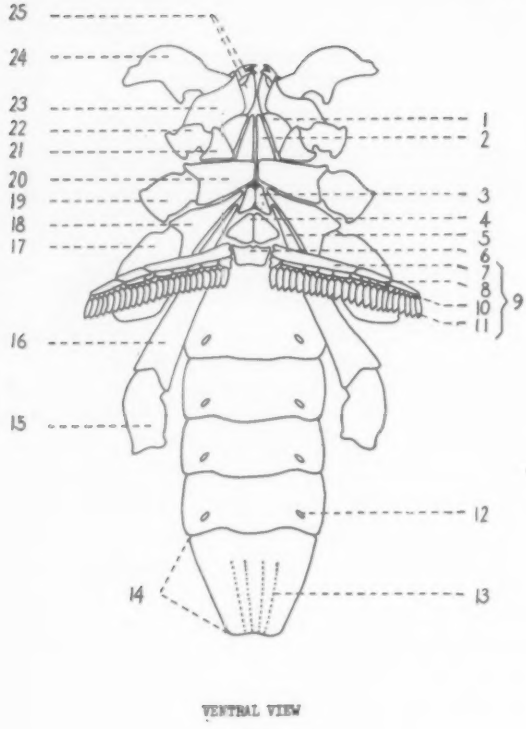

Figure 2

VENTRAL VIEW

1. Maxillary lobe I
2. Maxillary lobe II
3. Sternum
4. Genital plate (or operculum)
5. Coxa (4th leg)
6. Basal piece
7. Anterior lamellae
8. Median lamellae
9. Pectine
10. Fulcrum
11. Tooth
12. Stigma (spiracle)
13. Keel
14. Seventh abdominal segment
15. Trochanter (4th leg)
16. Coxa (4th leg)
17. Trochanter (3rd leg)
18. Coxa (3rd leg)
19. Trochanter (2nd leg)
20. Coxa (2nd leg)
21. Coxa (1st leg)
22. Trochanter (1st leg)
23. Coxa (1st leg)
24. Coxa (pedipalp)
25. Chelicera

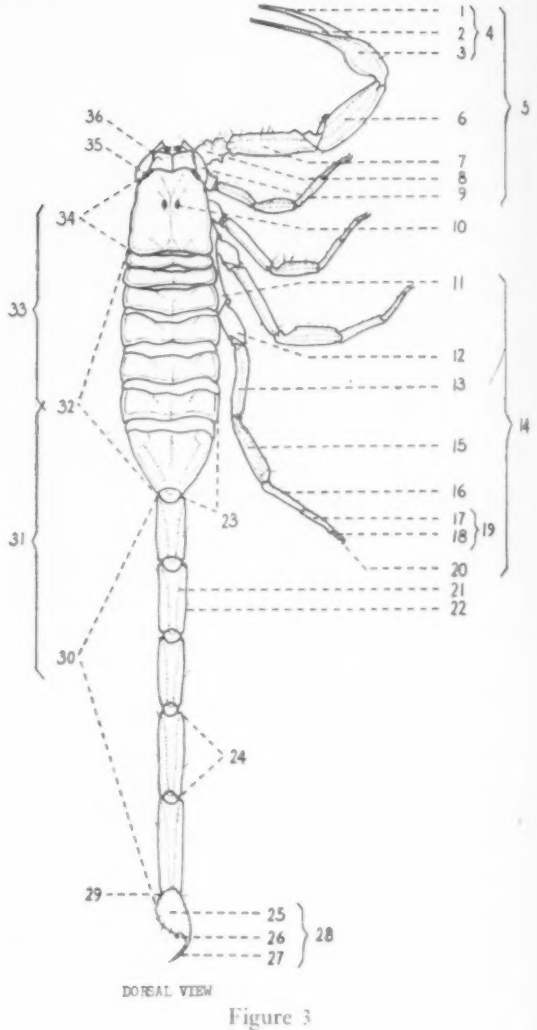

Figure 3

DORSAL VIEW LEGEND

1. Movable finger
2. Fixed finger
3. Palm
4. Chela (hand)
5. Pedipalp
6. Brachium (tibia)
7. Humerus (femur)
8. Trochanter
9. Coxa
10. Median eye
11. Coxa
12. Trochanter
13. Femur
14. Leg
15. Patella
16. Tibia
17. Protarsus
18. Tarsus
19. Tarsal joints
20. Claw
21. Dorsal keel
22. Superior lateral keel
23. Seventh pre-abdominal segment
24. Fourth caudal segment
25. Vesicle
26. Subaculear tooth
27. Aculeus
28. Telson
29. Anus
30. Cauda (Postabdomen)
31. Abdomen
32. Pre-abdomen
33. Trunk
34. Cephalothorax
35. Lateral eyes
36. Chelicera

The above drawings appeared on page 78 of the March 1957 issue of the ABT in an article titled "Scorpions for Laboratory Study." Through an error the labels were omitted. Since the scorpion structures are quite different from many of the other Arachnids, it was decided to reprint the illustrations with the labels. Our apologies to Herbert L. Stahnke who contributed this fine article.—The Co-Editors.

Three booklets, "Science-Fair Handbook for Exhibitors," "Science-Fair Handbook for Teachers," and "A Manual for Science Fairs," designed for science teachers, educators, and others who are interested in the planning of science fairs have been published by the Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

BOOKS FOR BIOLOGISTS

(Continued from page 155)

EVOLUTION: THE AGES AND TOMORROW, G. Murray McKinley, 275 pp., $4.00, The Ronald Press Company, New York, New York, 1956.

This book synthesizes facts and theories from many branches of knowledge to present an interpretation of evolution that gives a fresh understanding of man, the world of nature, and man's position in that world.

The author speculates on the origins of the cosmos and the earth, traces the evolutionary process in atoms and molecules, living cells, and increasingly complex animals, and dwells finally on the emergence of man and human society.

CROP PROTECTION, G. J. Rose, 223 pp., $10.00, Philosophical Library, New York, New York, 1955.

The book is written for the cultivator—whether large or small—faced with the problem of protecting his crops. It is a practical guide to the stored product. In addition, it is an aid to the planning of an intelligent programme of measures for combating insect pests, fungus diseases, and competing weeds.

THE FIRST AUSTRALIANS, Ronald and Catherine Berndt, 144 pp., $4.75, Philosophical Library, New York, New York, 1954.

The authors show the Aborigines first against the background of our own environment. Then the rich diversity of their life throughout the continent is unfolded: mythology and song; economy and social organization; trade and craftsmanship; ritual and ceremony.

HYPNOTIC SUGGESTION, S. J. VanPelt, 95 pp., $2.75, Philosophical Library, New York, New York, 1956.

This book tells the general medical practitioner and those intending to specialize in the treatment of psychoneurotic and psychosomatic disorders what they need to know about the modern method of treating these disorders by hypnotherapy.

BIOCHEMICAL INDIVIDUALITY, Roger J. Williams, 214 pp., $5.75, John Wiley and Sons, Inc., New York 16, N. Y., 1956.

A collection of available information on inter-individual variability with respect to anatomical and genetic enzyme levels, endocrine activities, nutritional needs, variations, and their implications in various areas.

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